

29. (Unamended) A head mounted display comprising the image display apparatus as set forth in Claim 6.

Please add new Claim 30 as follows.

--30. (New) The image display apparatus according to Claim 1, wherein said first optical member consists of a plurality of members that are cemented together.--

REMARKS

Applicants submitted a Preliminary Amendment on October 28, 2002, which apparently was not received by the Examiner before issuance of the November 4, 2002 Office Action. Since the status of that Preliminary Amendment is unclear (i.e., whether or not it has already been entered), Applicants are re-presenting herein the amendments set forth in the Preliminary Amendment.

Applicants respectfully request favorable reconsideration and allowance in view of the foregoing amendments and the following remarks.

Claims 1-30 are pending, with Claims 1, 7, 13, and 21 being independent. Claims 1, 7, 13, and 21 have been amended. No new matter has been added.

Applicants appreciate the indication that Claims 7-28 are allowed and submit that the amendments do not alter the allowability of those claims.

Applicants further appreciate the indication that Claims 6 and 29 are objected to but would be allowable if rewritten in independent form. Applicants have not rewritten those claims in that manner at this time because, for the reasons discussed below, Applicants submit that independent Claim 1 from which they depend is allowable.

Claims 1-5 stand rejected under 35.U.S.C. §102(a) as being anticipated by European Patent No. 1043619 A2 (Shi). Applicants respectfully traverse that rejection for the reasons stated below.

The present invention as recited in Claim 1 includes, *inter alia*, the feature of an optical surface A functioning as a reflecting surface in association with the illumination optical system and as a transmission surface in association with the display optical system, wherein the condition $20 \text{ deg} < \alpha < 70 \text{ deg}$ is satisfied, where α is an angle defined between the incident light and the reflected light of a reference ray when the reference ray is incident on and is reflected from optical surface A. Due to this feature, an apparatus can be made more compact yet have a well-structured optical system. As discussed, for example, at page 34, line 6 through page 35, line 10 of the specification, if the angle α is below 20 deg it is difficult to arrange the illumination optical system and the display means so as not to interfere with each other, and if the angle α is greater than 70 deg., the illumination optical system including the illumination light source becomes projected toward the eye side of an observer and the thickness of the apparatus increases to create a bulky apparatus.

As recited in Claim 1, the present invention also includes (among others) the feature wherein a reference ray that is part of the illumination light from the illumination means is substantially perpendicularly incident on the display means. As discussed for example at page 36, line 16 through page 37, line 2 of the specification, this feature permits degradation of the contrast to be prevented.

Applicants submit that the cited art fails to disclose or suggest at least the above-mentioned features of the present invention recited in Claim 1. Shi is completely silent as to the arrangement between the illumination means and the display means to satisfy the condition of the angle defined between the incident and reflected reference ray, as recited in Claim 1. There also is no disclosure or suggestion regarding the illumination

light being substantially perpendicularly incident on the display means. Moreover, Applicants submit that these features cannot be deemed inherent in Shi because they are not *necessarily* present in the apparatus Shi discloses.

For the foregoing reasons, Applicants submit that the present invention recited in Claim 1 is also patentable over the cited art. The dependent claims are patentable for the same reasons, as well as for the additional features they recite.

In view of the foregoing, Applicants submit that this application is in condition for allowance. Favorable consideration and early passage to issue are earnestly solicited.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,



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VERSION WITH MARKINGS SHOWING CHANGES MADE TO CLAIMS

1. (Amended) An image display apparatus comprising:

reflective display means;

illumination [light source] means for illuminating the display means;

an illumination optical system for guiding light from the illumination [light source] means to the display means; [and]

a display optical system for guiding light from the display means to an observation position [eye of an observer,

wherein the illumination optical system and the display optical system share only one surface of optical surface A having two functions of transmission and reflection with each other, wherein a reference ray emitted from the illumination light source means and passing a center of an image on the display means and a center of the eye is incident from the illumination light source means to the optical surface A, is reflected under a condition of an angle $\alpha(^{\circ})$ of $20 < \alpha < 80$ between the entering reference ray and the reflected reference ray on the optical surface A, is incident substantially normally to the display means, is reflected thereby, is transmitted through the optical surface A, is reflected by a plurality of decentered, reflective curvature surfaces, and thereafter is guided to the eye, and wherein the display optical system is comprised of an optical member comprising the optical surface A and another optical member having an optical refracting power, said optical members being placed with an air space in between];

a first optical member used in common by the illumination optical system and the display optical system and having only one surface of an optical surface A functioning as a reflecting surface in association with the illumination optical system and as a transmission surface in association with the display optical system; and

a second optical member having a refractive power and separated from said first optical member with an air-gap therebetween,

wherein light from said illumination means is reflected by said optical surface A and is guided to said display means,

wherein light from said display means is transmitted through said optical surface A and then is transmitted through said second optical member and guided to the observation position,

wherein, when a reference ray is defined as a ray that is part of illumination light from said illumination means that is reflected at the center of said display means and emerges therefrom and is incident on the center of a pupil, the following condition is satisfied,

$$20 \text{ deg} < \alpha < 70 \text{ deg.}$$

where, when in said illumination optical system the reference ray is reflected at said optical surface A, α is an angle defined by the incident light and the reflected light, and

wherein the reference ray is substantially perpendicularly incident on said display means to emerge substantially perpendicularly therefrom and said display optical system includes a plurality of reflecting surfaces of decentered curvature surfaces in said second optical member.

7. (Amended) An image display apparatus comprising:
- reflective display means;
 - illumination [light source] means for illuminating the display means;
 - an illumination optical system for guiding light from the illumination [light source] means to the display means; [and]

a display optical system for guiding light from the display means to an observation position [eye of an observer,

wherein an optical surface A having two functions of transmission and reflection, shared between the illumination optical system and the display optical system, has a curvature on a local meridional section (a plane including incident light and exit light of a reference ray emitted from the illumination light source means and passing a center of an image on the display means and a center of the eye), wherein when local_fy represents a focal length in the local meridional section of the display optical system and local_fyA a focal length in the local meridional section of only the optical surface A in the illumination optical system, a ratio of the focal lengths satisfies the following condition:

$$0.1 < \text{local_fyA/local_fy} < 1.0,$$

wherein rays emitted from the illumination light source means are reflected by the optical surface A to illuminate the display means and the reflected light from the display means is transmitted through the optical surface A, is reflected by a plurality of reflective surfaces, and thereafter is guided to the eye];

a first optical member used in common by said illumination optical system and said display optical system and having an optical surface A functioning as a reflecting surface in association with said illumination optical system and as a transmission surface in association with said display optical system; and

a second optical member;

wherein light from said illumination means is reflected by said optical surface A and is guided to said display means;

wherein light from said display means is transmitted through said optical surface A and then is transmitted through said second optical member to be guided to the observation position.

wherein, when a reference ray is defined as a ray which is illumination light from said illumination means that is reflected at the center of said display means and emerges therefrom and is incident on the center of a pupil, and a plane that includes incident light and exit light of the reference ray in each surface is defined as a local meridional section in each surface, the following condition is satisfied,

$$0.1 < \text{local.fyA} / \text{local.fy} < 1.0,$$

where local.fy is a focal length of said display optical system in the local meridional section and local.fyA is a focal length of said optical surface A, and

wherein said display optical system includes a plurality of reflecting surfaces in said second optical member.

13. (Amended) An image display apparatus comprising:
- reflective display means;
 - illumination means for illuminating the display means;
 - an illumination optical system for guiding light from the illumination means to the display means; [and]
 - a display optical system for guiding light from the display means to an observation position [toward an observer, wherein the illumination optical system and the display optical system share an optical surface A having two functions of transmission and reflection with each other, the optical surface A has a curvature on a local meridional section (a plane including incident light and exit light of a reference ray emitted from the illumination means and passing a center of an image on the display means and a center of the pupil), a curved surface B is provided on the opposite side of the optical surface A to the display means, and the optical surface A and optical surface B compose a lens

body, wherein rays emitted from the illumination means are reflected by the optical surface A of the lens body to illuminate the display means, and the reflected light from the display means is transmitted by the optical surface A to enter the lens body and then emerge from the optical surface B, is then reflected by a plurality of reflective surfaces, and thereafter is guided to the pupil to form an enlarged image of the image displayed on the display means, and wherein when local_ryA represents a radius of curvature in the local meridional section, at a point of intersection with the reference ray on the optical surface A of the lens body in the display optical system and local_ryB a radius of curvature in the local meridional section, at a point of intersection with the reference ray on the curved surface B, local_ryA and local_ryB have an identical sign and satisfy the following condition:

$$0.4 < \text{local ryA} / \text{local ryB} < 2.0.]$$

a first optical member used in common by said illumination optical system and a display optical system and having an optical surface A functioning as a reflecting surface in association with said illumination optical system and as a transmission surface in association with said display optical system; and

a second optical member,

wherein from said illumination means is reflected by said optical surface A and is guided to the display means;

wherein light from said display means is transmitted through said optical surface A and then is transmitted through said second optical member to be guided to the observation position,

wherein said first optical member has an optical surface B opposed to said optical surface A facing toward said display means so that light from said display means is

transmitted through said optical surface A and thereafter is transmitted through said optical surface B, said optical surface A has a curvature and said optical surface B is a curved surface.

wherein, when a reference ray is defined as a ray which is illumination light from said illumination means that is reflected at the center of said display means and emerges therefrom and is incident on the center of a pupil, and a plane that includes incident light and exit light of the reference ray in each surface is defined as a local meridional section in each surface, the following condition is satisfied,

$$0.4 < \text{local.rvA} / \text{local.rvB} < 2.0,$$

where local.rvA and local.rvB are radius of curvature of said optical surface A and a radius of curvature of said optical surface B in the local meridional section, respectively, and have the same sign, and

wherein said display optical system includes a plurality of reflecting surfaces in said second optical member.

21. (Amended) An image display apparatus comprising:

reflective display means;

illumination means for illuminating the display means;

an illumination optical system for guiding light from the illumination means to the display means; [and]

a display optical system for guiding light from the display means to an observation position [toward an observer,

wherein the illumination optical system and the display optical system share an optical curvature surface A having two functions of transmission and reflection with each other, a curved surface B is provided on the opposite side of the optical curvature surface A

to the display means, and the optical curvature surface A and the curved surface B compose a lens body, wherein rays emitted from the illumination means are reflected by the optical curvature surface A of the lens body to illuminate the display means, and the reflected light from the display means is transmitted by the optical curvature surface A, is incident to the lens body, emerges from the curved surface B, is reflected by a plurality of reflective surfaces, and thereafter is guided to the pupil to form an enlarged image of the image displayed on the display means, wherein in an outermost image on a local meridional section of the display means (a plane including incident light and exit light of a reference ray emitted from the illumination means and passing a center of an image on the display means and a center of an eye), when an F3 eye center ray represents a ray passing the center of the eye and an outermost image height F3 on the far side from the eye and when an F2 eye center ray represents a ray passing the center of the eye and an outermost image height F2 on the near side to the eye, an optical path length of the F3 eye center ray in the lens body in the display optical system is longer than that of the F2 eye center ray]

a first optical member used in common by said illumination optical system and said display optical system and having an optical surface A functioning as a reflecting surface in association with said illumination optical system and as a transmission surface in association with said display optical system; and

a second optical member;

wherein illumination light from said illumination means is reflected by said optical surface A and is guided to said display means;

wherein light from said display means is transmitted through said optical surface A and then is transmitted through said second optical member to be guided to the observation position.

wherein said first optical member has an optical surface B opposed to said optical surface A facing toward said display means so that light from said display means is transmitted through said optical surface A and thereafter is transmitted through said optical surface B, said optical surface A has a curvature and said optical surface B is a curved surface.

wherein, when a reference ray is defined as a ray that is illumination light from said illumination means that is reflected at the center of said display means and emerges therefrom and is incident on the center of a pupil, and a plane that includes incident light and exit light of the reference ray in each surface is defined as a local meridional section in each surface, in the local meridional section of a display means surface, the optical path length of a ray, in said first optical member, that passes a most peripheral image on said display means at a far side from the observation position and a center of the pupil is longer than the optical path length of a ray, in said first optical member, that passes a most peripheral image on said display means at a near side from the observation position and the center of the pupil, and

wherein said display optical system includes a plurality of reflecting surfaces in said second optical member.